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"2008 – Año de la enseñanza de las Ciencias"

EXAMEN TECNICO DE FONDO	SOLICITUD Nº: P050102456

4. CLASIFICACIÓN

Int. Cl[7]: **B21B 27/10, 19/04, 45/02**

5. BÚSQUEDA

Campo de la Búsqueda: B21B

6. RESULTADO DE LA BÚSQUEDA

Documento Nro.	Categoría	Documento	Relevante para la(s) Reivindicacion(es) Nº
1	X,Y	JP 8215717 A – 27/08/96 – (Doc. Compl.) – Figs. 1 a 8 y Des.	1-5, 6-7, 8-10, 11 — previously cited
2	X,Y	JP 6015311 A – 25/01/94 – (Doc. Compl.) – Figs. 1 a 6 y Des.	1-5, 6-7, 8-10, 11 — previously cited
3	Y	AR197861 – 15/05/74 – (Reivs. y Dibs.) – Fig. 2 y Reivs. 1 y 2.	1-5, 6-7, 8-10, 11

CATEGORÍA DE LOS DOCUMENTOS CITADOS

"X" Documento de particular relevancia si es considerado solo, afecta la Novedad o la Actividad Inventiva.

"Y" Documento de particular relevancia combinado con otro(s) de la misma categoría, afecta la Actividad Inventiva.

"A" Documento perteneciente al Estado de la Técnica.

"D" Documento citado en la solicitud.

"B" Documento surgido de las Observaciones de Terceros.

"L" Documento citado por otras razones.

"S" Solicitud conflictiva (Art. 15 Ley 24.481)

"O" Divulgación no escrita.

"T" Documento citado para entender el principio o teoría bajo la cual se desarrolla la invención.

"&" Documento de la misma familia de patentes.

Partial Translation of Search Report
From Argentine Office Action

Doc. No.	Category	Document	Relevant for Claims No.
1	X, Y	JP 8215717 A - 27/08/96 - (Whole document) - Figs. 1 to 8 and Des.	1-5, 6-7, 8-10, 11
2	X, Y	JP 6015311 A - 25/01/94 - (Whole document) - Figs. 1 to 6 and Des.	1-5, 6-7, 8-10, 11
3	Y	AR197861 - 15/05/4 (Claims and Figures) -Fig. 2 and Claims 1 and 2	1-5, 6-7, 8-10, 11

COMBINACION DE UN JUEGO DE CILINDROS LAMINADORES CON UN APARATO PARA DISTRIBUIR UN LIQUIDO SOBRE UNA SUPERFICIE, Y UN METODO PARA APLICAR UN LIQUIDO A LOS CILINDROS LAMINADORES DE UN JUEGO DE CILINDROS CON AYUDA DE DICHA COMBINACION

Publication number:	AR197861
Publication date:	1974-05-15
Inventor:	
Applicant:	EXXON CO (US)
Classification:	
- international:	*B05B13/00; B05B13/02; B05B15/08; B05C1/08; B05D1/02; B21B27/10; B21B45/02;* B05B13/00; B05B13/02; B05B15/00; B05C1/08; B05D1/02; B21B27/06; B21B45/02;
- European:	B05B13/02A; B05B15/08; B05D1/02; B21B27/10; B21B45/02C4L12
Application number:	AR19700227199 19700227
Priority number(s):	GB19690010778 19690228

Also published as:

- US3656330 (A1)
- GB1296991 (A)
- FR2035744 (A5)
- DE2009424 (A1)
- BE746625 (A)

more >>

Abstract not available for AR197861

United States Patent

Brown et al.

[15] 3,656,330

[45] Apr. 18, 1972

[54] **SYSTEM FOR DISTRIBUTING LIQUID OVER A SURFACE**

[72] Inventors: **Thomas W. Brown**, Didcot; **John S. Lemlin**, Wantage, both of England

[73] Assignee: **Esso Research and Engineering Company**

[22] Filed: **Feb. 20, 1970**

[21] Appl. No.: **13,077**

[30] **Foreign Application Priority Data**

Feb. 28, 1969 Great Britain 10,778/69

[52] U.S. Cl. **72/10**, 72/45, 72/201, 72/236, 148/156, 148/157

[51] **Int. Cl.** **B21b 37/00**, B21b 45/02, B21b 27/10

[58] **Field of Search** ....72/41, 43, 44, 45, 201, 202, 72/236, 10, 16; 148/156, 157; 266/4 S, 6 S

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Primary Examiner—Richard J. Herbst
Assistant Examiner—E. M. Combs
Attorney—Pearlman and Stahl and Frank T. Johmann

[57] **ABSTRACT**

Liquid is distributed at a substantially desired uniform rate per unit area on a surface having a dimension which varies in a predetermined manner by projecting at the surface a divergent stream of the liquid from a nozzle which can be moved towards and away from the surface, the rate of supply of liquid to the nozzle being substantially proportional to the distance between the nozzle and the surface. The invention is useful in applying a wear-resisting liquid coating to the rolls of hot metal rolling stand, the chosen rate of discharge being sufficient to mitigate wear of the work rolls without derogating from their performance.

26 Claims, 6 Drawing Figures

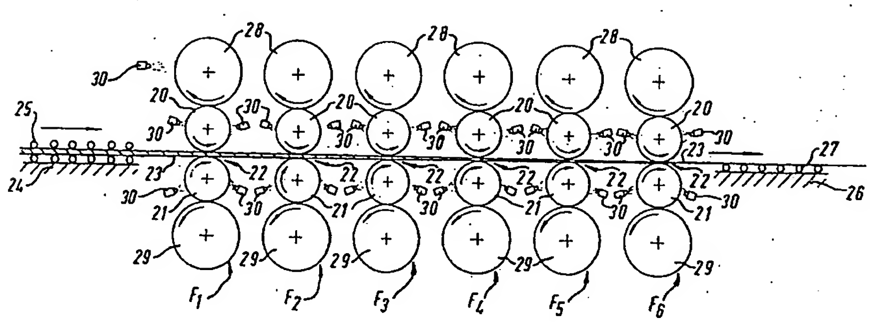


FIG. 1.

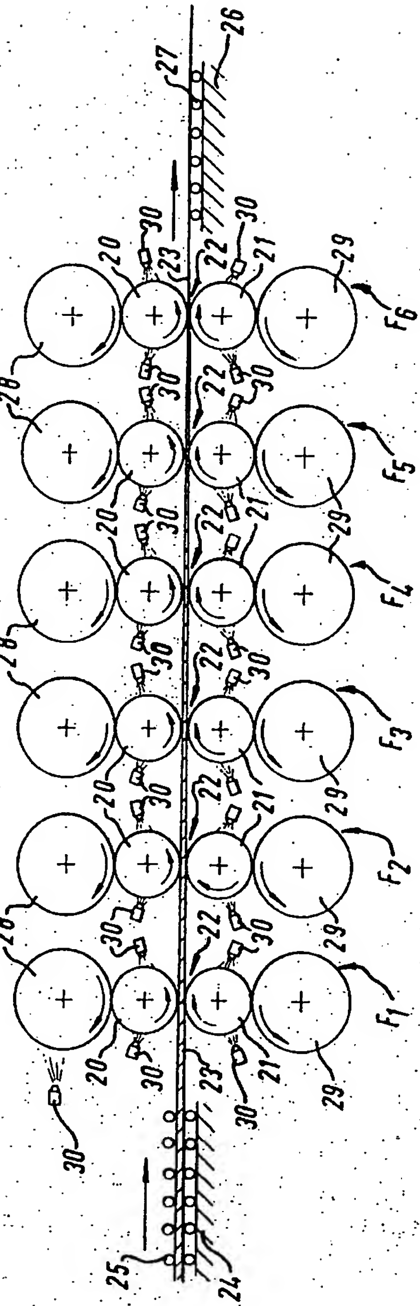
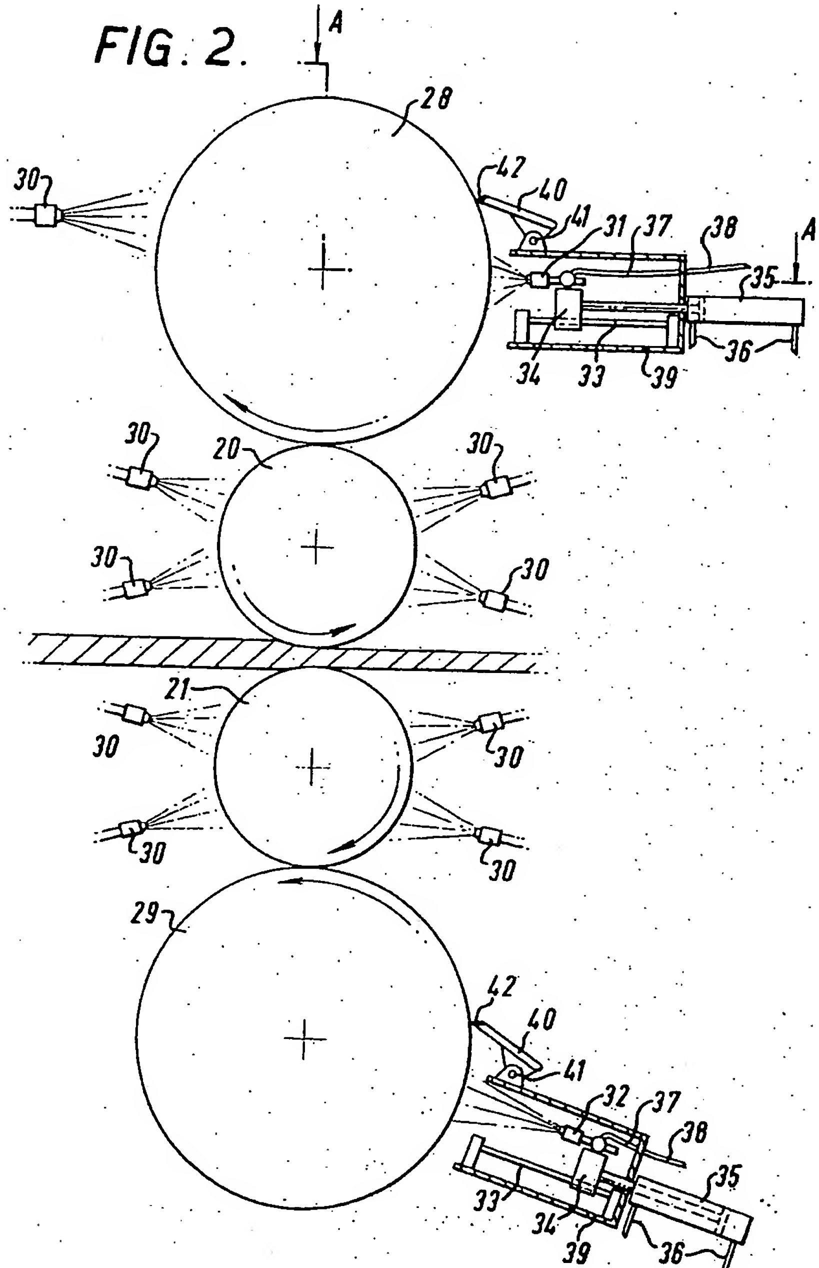


FIG. 2.


A
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30
21
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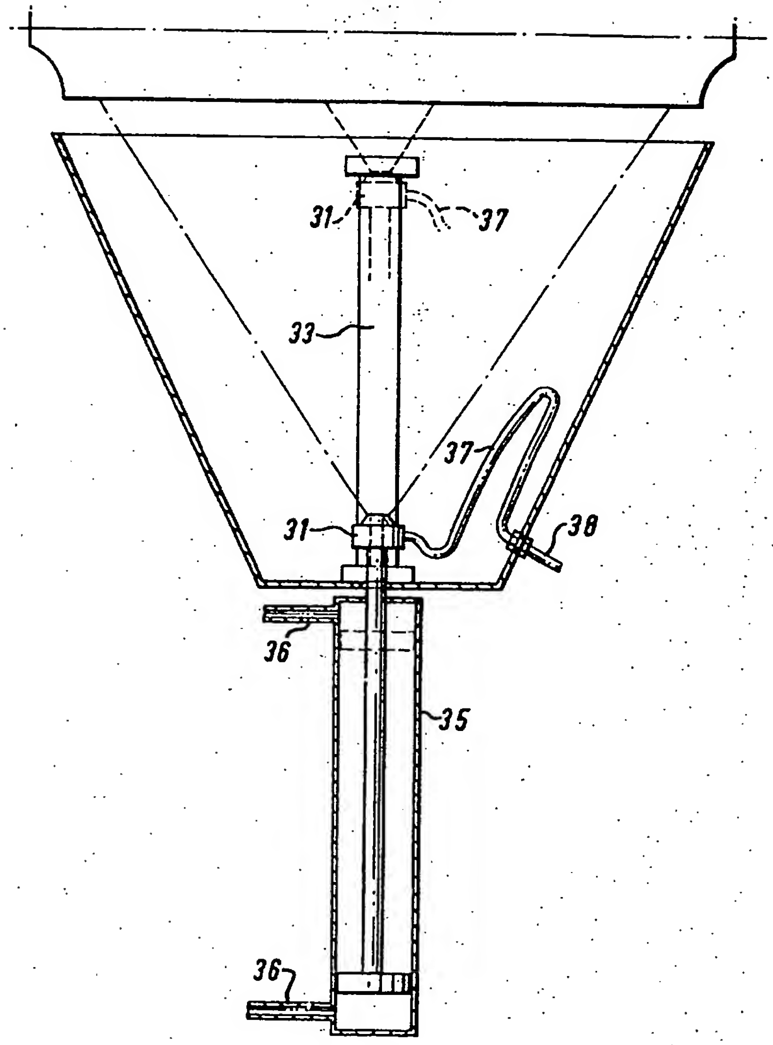
FIG. 3.



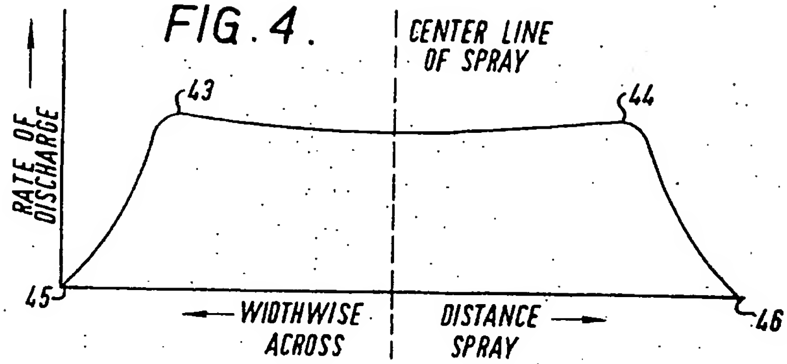
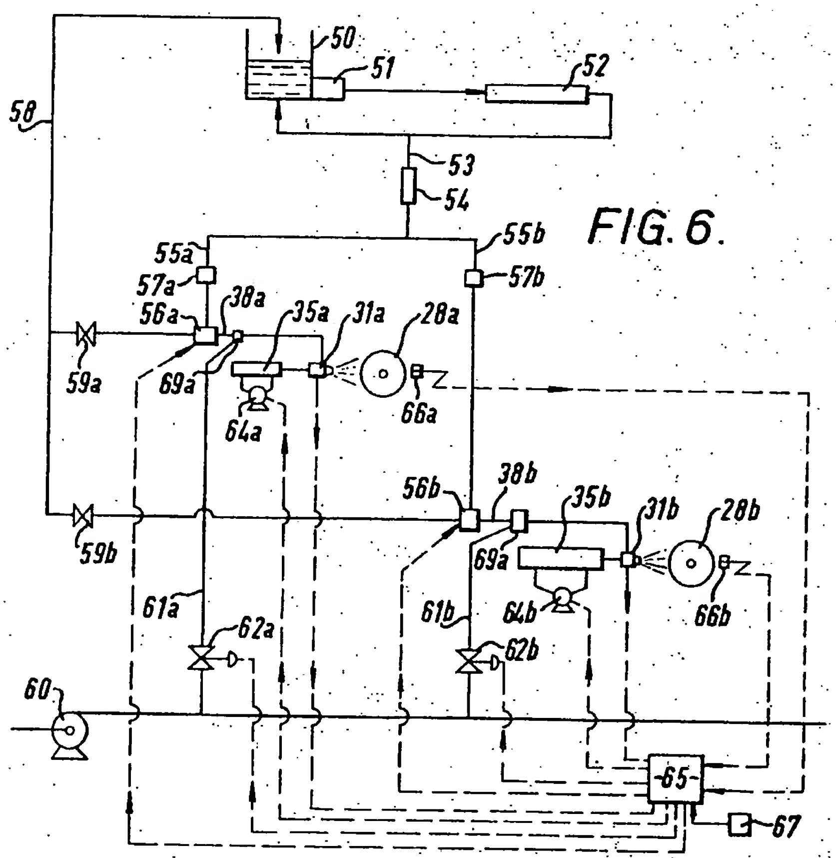

RATE OF DISCHARGE
CENTER LINE OF SPRAY
43
44
45
46
WIDTHWISE DISTANCE ACROSS SPRAY

FIG. 4.


50
51
52
58
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55a
55b
57a
57b
56a
38a
35a
31a
28a
59a
69a
64a
66a
56b
38b
35b
31b
28b
59b
69a
64b
66b
61a
62a
61b
62b
60
65
67

FIG. 6.

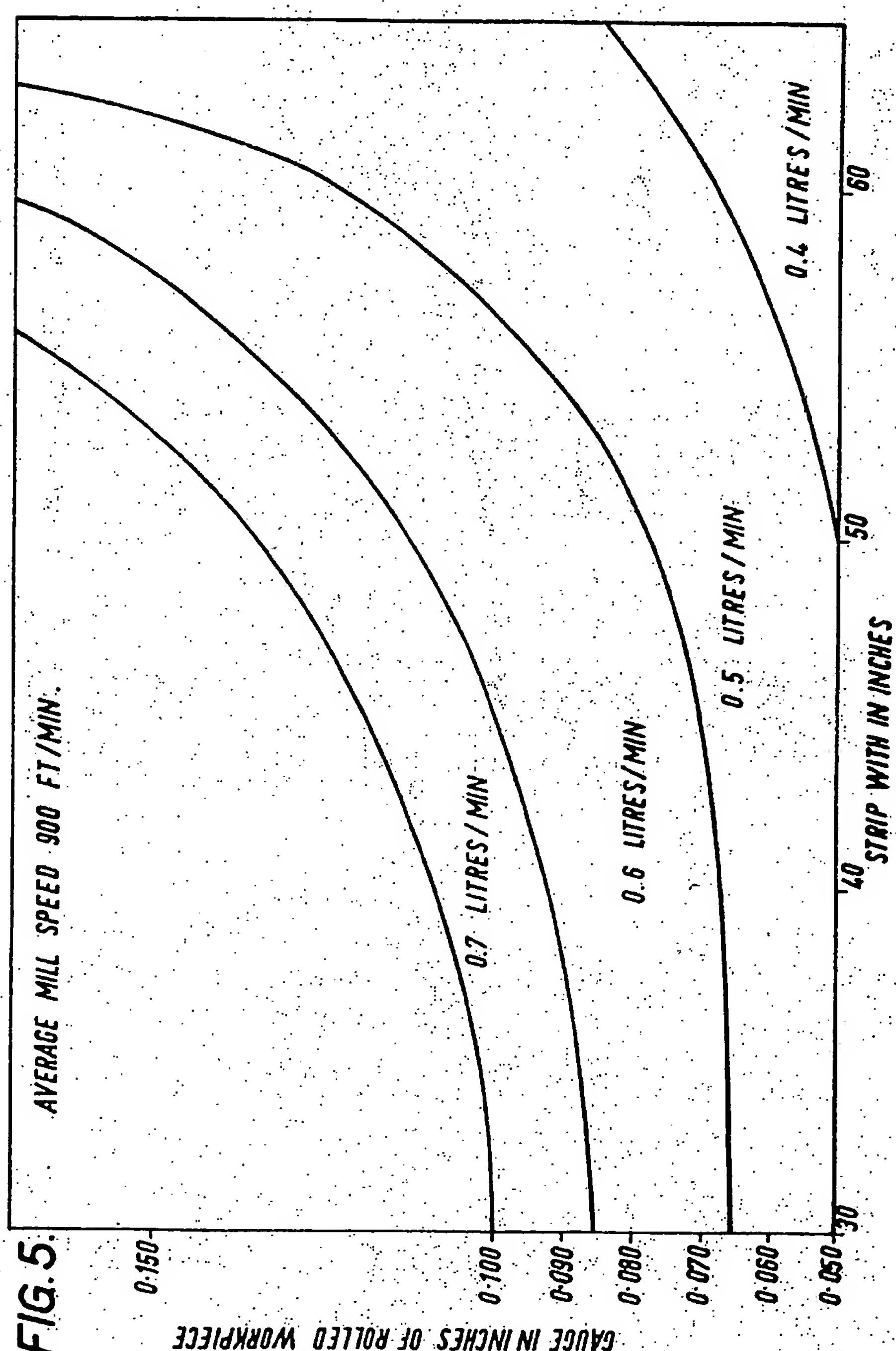
AVERAGE MILL SPEED 900 FT/MIN.
0.7 LITRES/MIN
0.6 LITRES/MIN
0.5 LITRES/MIN
0.4 LITRES/MIN
30
40
50
60
STRIP WITH IN INCHES
0·150
0·100
0·090
0·080
0·070
0·060
0·050
GAUGE IN INCHES OF ROLLED WORKPIECE

FIG. 5.

SYSTEM FOR DISTRIBUTING LIQUID OVER A SURFACE

The present invention relates to a method and apparatus for distributing a liquid over a surface.

In certain operations, it is required or desirable to distribute a liquid evenly over selected areas of a surface.

In particular instances of such operations, as in the application of coating liquids such as paints, inks or lubricants, the selected areas change from time to time and/or from place to place, and the dimensions of the selected areas change correspondingly.

The present invention is particularly, although not exclusively, concerned with the application of a liquid to the surfaces of the rolls of hot metal strip rolling mills. Known expedients for carrying out such operations are of two main types. In the first type, the liquid is sprayed onto the surface from a nozzle at a fixed distance from the surface with a pressure which is caused to increase as the dimension of the selected area increases. In this type, the nozzle is so designed that changes in the pressure at which liquid is supplied to the nozzle causes a change in the angle of divergence of the boundaries of the spray away from the nozzle, so that when an area of relatively large dimension is to be coated, the liquid is supplied at a high pressure and when an area of relatively smaller dimension is to be coated, the liquid pressure is reduced. This type of liquid distribution system is unsatisfactory in the respect that when the delivery pressure of liquid to the nozzle is varied, the quantity of liquid distributed per unit area of the sprayed surface also varies.

In a second type of liquid distribution system, there is provided a plurality of nozzles at a fixed distance from the surface which is to be coated, and as the dimension of the area which is to be coated varies, the number of nozzles from which liquid is sprayed is also varied. This type of distribution system is not altogether satisfactory as the amount of liquid sprayed is not uniform on each unit of area, and difficulties are experienced in precisely determining the correct number of nozzles which should be operational to distribute liquid over the selected areas of varying dimensions.

According to this invention, a liquid is distributed at a substantially desired uniform rate per unit area onto selected areas of a surface, which areas have a dimension which varies in a predetermined manner, by projecting the liquid in a divergent stream towards the surface from a nozzle which is mounted for movement towards and away from the surface, the rate of liquid flow rate through the nozzle being increased with increasing distance between the nozzle and the surface, and decreased with decreasing distance between the nozzle and the surface so that the substantially desired uniform rate of distribution of liquid per unit area of the surface can be maintained.

Preferably, for a required delivery rate of liquid per unit area of the surface, the flow-rate of liquid through the nozzle is coordinated automatically with the distance of the nozzle from the surface in a predetermined manner, although it is contemplated that the coordination of the liquid delivery rate and nozzle-to-surface distance may be achieved by manual adjustment.

The invention is particularly applicable to rolling mills used for reducing the thickness of metal billets or strip or for modifying the metallurgical properties of the metal.

In such rolling mills, the metal which is to be processed by the rolling mill is passed between a pair of opposed work rolls which apply a suitable pressure to the metal to effect the required change to the metal.

The work rolls suffer considerable wear during the metal rolling process, and it has been found that the rate of wear is reduced if a suitable lubricant or wear-resisting coating or film is provided on the work rolls. Apart from the cost of providing replacement work rolls, considerable production losses result during the time required for replacement of the worn work rolls by new work rolls.

The problem of wear of the work rolls is particularly acute in the rolling of hot metal when the metal temperature may be as high as 1,300° C., since 20 to 30 minutes are required for worn work roll replacement, and each pair of work rolls can be operative only for 1,000 to 1,200 tons of metal (in the case of steel strip) before replacement is necessary.

A typical hot metal strip rolling mill comprises a number of roll stands through which the strip is passed successively. Each roll stand comprises, besides the opposed work rolls between which the metal strip is passed, a pair of back-up rolls which are separated by the pair of work rolls and which apply the rolling force to the work rolls.

Usually, there are six (or thereabout) such roll stands in a rolling mill, and the third stand, or its equivalent, effects the major part of the rolling, and consequently the work rolls thereof suffer the most wear and damage and need to be changed most frequently. The benefits of the invention arise most particularly in respect of reduced wear in these work rolls, and their back-up rolls, although the invention is also advantageous in respect of work rolls and back-up rolls of other roll stands of the mill.

When the mill is first run with newly installed work rolls, the first strip of the work schedule which is run through the mill is initially relatively narrow strip, and tends to have minor surface defects and misalignments: subsequent strips which are run through the mill are of increased width and have a better finish until, when the work rolls have attained their optimum temperature and surface quality, the widest strip is run through the mill. The widest strip is the most difficult to roll satisfactorily, but at this optimum stage of temperature and surface quality, the best quality strip, suitable for use in automobile manufacture, is obtained. Thereafter, the quality of the finish deteriorates and strips of successively narrower width are run through the mill. The gradual change in width of the rolled strips initially from the narrowest to the widest, and then more gradually to narrower widths has obtained for this program of rolling the name "coffin schedule." Generally speaking, it is customary to change the work rolls of the third roll stand and sometimes of the second roll stand after about one third of the strips following the widest strip have been rolled (the so-called "intermediate roll change") and to change all the work rolls at the end of the coffin schedule (the so-called "general roll change"). About one each week there is a down time in which all the rolls of the mill, including the back-up rolls, are replaced.

In one application of the present invention to metal rolling, a nozzle is mounted for movement towards and away from the surface of each work roll, and a suitable lubricant or wear-resisting coating is applied to each work rolls from its respective nozzle. In the initial phase of the coffin schedule, the width of the metal strip increases from strip to strip, and lubricant or coating is required over the increased width of each roll which is in contact with the strip.

Similarly, after the widest strip of the coffin schedule has been rolled, the width of subsequent metal strips decreases and the width of the work rolls which needs to be coated decreases.

The said nozzles are moved to be relatively close to their respective work rolls where the width of the worked metal is relatively small and when the width of the worked metal is increased, the nozzles are incrementally moved away from their respective work rolls in steps which are coordinated with the changes in metal width during the coffin schedule, the rate of liquid discharge from the nozzles being correspondingly increased to ensure that liquid is supplied to the metal rolling area of the work rolls substantially at a desired uniform rate per unit area.

The divergent spray of liquid from the nozzles preferably has a width which is a fixed proportion of the width of the metal strip: it is preferred that the spray width is slightly greater than the metal width since at the edges of the spray, the flow-rate of liquid is less than in regions away from the edges, and is non-uniform: a suitable width of spray for most applications would be 110–120 percent of the width of the workpiece.

During the rolling operation, it is desirable that the rate of wear-resisting liquid distribution per unit area of the work rolls is maintained at critical controlled values. Too much wear-resisting liquid on the work rolls can result in slipping of the worked metal through the bite of the work rolls with inadequate rolling, and too little wear-resisting liquid on the rolls results in increased wear.

Accordingly, the rate of supply of liquid to each nozzle is coordinated with the operation condition of the work rolls in a manner which depends on the characteristics of the liquid, the gauge of the metal and its quality, the supply being increased as the working width of the rolls increases, and decreased as the working width of the rolls decreases. Thus generally speaking, the coordinated movement of the nozzles, liquid supply rate and working width of the work rolls ensures that substantially a constant distribution of liquid at substantially the optimal rate per unit area of the working width of the work rolls is provided.

Advantageously, the liquid projected from each nozzle may comprise a carrier liquid, conveniently water, and a dispersion therein of the wear-resisting liquid. The carrier liquid is preferably discharged continuously from each nozzle to avoid the risk of blockage of the nozzles while the wear-resisting liquid is dispersed in the carrier for discharge therewith preferably at predetermined periods in accordance with the operating program. Another advantage of providing a continuous discharge of the carrier liquid is that when wear-resisting liquid is supplied to the nozzles, there is substantially no time lag between the entrance and exit of the wear-resisting liquid relative to the nozzles which would otherwise be unavoidable while a suitable discharge pressure of wear-resisting liquid built up within the nozzles.

It is preferred that no wear-resisting liquid is sprayed onto the work rolls when metal is to be first introduced in the bite between the rolls: this is to enable a firm grip to be made on the "head" end of the metal and to avoid the possibility of a failure of the work piece to enter the bite. The interruption of the supply of wear-resisting liquid to the work rolls at the beginning of a working cycle may be achieved automatically e.g. in response to a signal from a metal detector of any type on a preceding roll stand.

In the rolling of hot metal, the supply of wear-resisting liquid to the work rolls is interrupted before the tail end of the workpiece enters the bite of the work rolls. This interruption may also be achieved automatically as part of the work program, e.g., in response to a signal from a metal detector on a subsequent roll stand, and enables residual liquid on the work rolls to be volatilized and/or burnt off by the hot tail end of the workpiece (or, in certain cases depending on the nature of the liquid, it may be washed off by the carrier liquid or rolling mill coolant liquid) so that the bite is free of wear-resisting liquid when the next workpiece is presented for rolling, and the possibility of slippage in the bite is mitigated or eliminated.

Preferably the wear-resisting liquid that is distributed over the selected working area of the work rolls is of a type that can be removed by volatilization and/or oxidation at the working temperature. In this respect, esters are advantageous, particularly esters of the sterically hindered type in which the alcohol and/or acid residue in each molecule comprises at least one carbon atom which is attached to four other carbon atoms.

In order to enhance the tendency of the ester to stick to the rolls, free carboxylic acids and partial esters having non-esterified hydroxyl groups may be incorporated with the ester.

In hot metal rolling, the work rolls are generally urged towards each other by so-called back-up rolls.

Preferably, for hot metal rolling, the movably mounted nozzles are arranged for spraying the wear-resisting liquid, for preference, dispersed in the carrier liquid, onto the back-up rolls rather than onto the work rolls, each back-up roll then distributing the liquid over the work roll with which it is in contact.

The movement of the nozzles, together with the corresponding variation of liquid feed-rate therethrough in accordance with the rolling program may also be initiated and regulated by the previously mentioned metal detectors, so that during a "coffin schedule" of hot metal rolling, as the head end of a relatively narrow metal workpiece enters the work roll bite at the beginning of the schedule, no wear-resisting liquid is sprayed onto the back up rolls, although a spray of carrier liquid is discharged from the nozzles, and the work rolls are able to take a firm grip on the workpiece. The nozzles at this stage of the schedule are located relatively closely to their respective back-up rolls so that carrier liquid is sprayed over a width of the back-up rolls just exceeding the width of the workpiece. When the workpiece is gripped in the bite, the supply of wear-resisting liquid is initiated, and a dispersion of carrier liquid and wear-resisting liquid is discharged from the nozzles. As the work-cycle proceeds, wider workpieces are passed into the rolling mill, and the nozzles are accordingly displaced away from their respective back-up rolls so that correspondly increased widths thereof are sprayed, which may be 110 percent to more than 120 percent of the width of the workpiece, depending on the nature of the carrier liquid. Simultaneously, the rate of discharge of liquid from the nozzles is increased whereby to maintain at a substantially constant and uniform value the rate of liquid supply per unit area of back-up roll which is sprayed.

After a short part of the coffin cycle, the metal workpieces will have a width approximating to the width of the work rolls and correspondingly, the nozzles will have been withdrawn to a maximum distance from their respective back-up rolls and the discharge rate of liquid through each nozzle will have attained a maximum value for the gauge of strip, the quality of the metal and the nature of the wear-resisting liquid.

In accordance with the "coffin schedule," the widths of subsequent workpieces are incrementally decreased and correspondingly, in accordance with the invention, the nozzles are moved inwardly towards their respective back-up rolls so that the width of back-up roll sprayed is, say, approximately 110 to 120 percent of the widths of the workpieces, and the rate of liquid delivery from the nozzles is decreased to maintain the required rate of distribution per unit area of the back-up rolls, and consequently, of the work rolls.

The supply of wear-resisting liquid is interrupted when the tail end of the workpiece approaches the bite so that, as previously mentioned, the heat of the tail end of the workpiece will cause volatilization and/or burning off of any wear-resisting liquid which has not been washed from the work rolls by the carrier liquid and/or the mill coolant, thus preparing the work rolls for gripping the head end of a subsequent workpiece.

Preferably each movable nozzle is so designed that the divergent spray therefrom is concentrated in one plane. A hollow triangular hood or shroud may be provided to enclose the spray and thereby protect it from dispersal or deflection by currents of air, stream or water. Preferably each shroud is fixedly located relative to the roll stand, and all movement of the nozzle takes place within the shroud.

It is general practice in the art to provide substantial streams of cooling water which flow over the rolls of each roll stand. These streams of water can remove the layer of wear-resisting liquid in part or wholly from the rolls, and to avoid this possibility, it is useful to provide a deflector above each shroud which extends the full width thereof. The deflector bridges the gap between the shroud and the roll adjacent the shroud. When the wear-resisting liquid is sprayed towards the back-up roll or work roll, either alone or dispersed in a coolant liquid, the deflector serves as an umbrella for the spray against the downward falling streams of water, and the sprayed liquid is therefore protected against deflection or dispersion by the water streams, and the wear-resisting liquid is able to form a wear-resistant layer on the surface of the sprayed roll. Once the wear-resistant layer has been formed, it is not, or should not be, substantially reduced in thickness by the cooling water streams which are encountered when the sprayed roll surface moves out of the region protected by the deflector: this can be ensured by providing a suitable formulation for the wear-re-

sisting liquid. If, however, the formulation of the liquid is such that some reduction in thickness of the film will take place, the amount of wear-resisting liquid sprayed onto the rolls should be increased to take account of this, so that the appropriate thickness of wear-resisting film remains on the work rolls at the bite of each roll stand.

The deflector may take the form of a plate which is hinged on one side to the top of the corresponding shroud or any other member which is fixedly located relative to the roll stand and rests by its own weight and/or under the action of a light spring on its opposite side against the surface of the sprayed roll. Advantageously the said opposite side of the deflector has an edge region of suitable wear resisting or anti-friction material which preferably does not absorb the wear-resisting liquid such as nylon or polytetrafluroethylene: the remainder of the deflector may be of any durable rigid material such as wood, plastic or mild steel. From time to time, the deflector will be so worn due to rubbing on the roll surface that it will need to be discarded.

The nozzle design may be either of the type in which the angle subtended by the divergent spray is either dependent to some extent on the liquid feed pressure to the nozzle, or is independent of the liquid feed pressure.

Each nozzle may be mounted on a carriage for movement towards and away from a respective back-up roll. The carriage may be movable by pneumatic, hydraulic, mechanical or electrical means, and a valve or throttle system, which may be automatic in operation, or under manual control, is provided to ensure that the distribution of liquid onto the back-up or work roll proceeds at a predetermined constant rate per unit area according to the operating conditions whatever the relative positions of the rolls and nozzles. Suitable means responsive to the relative positions of the workpiece and the rolls are provided so that the supply of wear-resisting liquid is initiated after the leading edge of the workpiece has entered the bite of the work rolls, and terminated as the trailing edge of the workpiece approaches the bite.

It is preferred that when the wear-resisting liquid, whether ester or mineral oil or other coating liquid is distributed onto the work rolls, the spraying is effected from such a position that the wear-resisting layer of liquid has the smallest possible distance to travel before contacting the heated metal workpiece i.e. the liquid should reach as near as possible to the part of the work roll which is about to enter the work roll bite. In cases where the liquid is distributed onto the back-up roll, each nozzle is directed as nearly as possible at that part of the respective back-up roll which is about to contact the adjacent work roll. In practice, the actual positioning of the nozzles may not always be in the afore-mentioned most advantageous positions due to the interposition of other necessary parts of the rolling mill or other plant equipment.

The invention will now be described with reference to the accompanying drawings depicting various exemplary embodiments of the invention, and in which

FIG. 1 is a general schematic side elevation of a hot metal strip rolling mil,

FIG. 2 illustrates one stand of the rolling mill of FIG. 1 and means for distributing liquid over the rolls thereof,

FIG. 3 is a simplified sectional plan view of part of FIG. 2, the section being taken along lines A—A,

FIG. 4 is a graph showing a typical distribution of liquid from a spray nozzle,

FIG. 5 illustrates graphically a typical relationship between the width of a workpiece which is to be rolled and the thickness of gauge of the workpiece for various flow rates of one type of wear-resisting coating fluid or lubricant, and

FIG. 6 shows schematically a part of a rolling mill and a control system for controlling the mill, in accordance with the invention.

Referring to FIG. 1, there is shown the main components of a hot metal rolling mill having six rolling stands, F_1 to F_6. Each rolling stand comprises a pair of opposed work rolls 20, 21 between which is defined a bite 22 through which passes the metal workpiece 23 which is being rolled.

At the feed end of the first stand F_1 is a support table 24 having feed rollers 25 for the workpiece 23 while at the discharge end of the last stand F_6 is a support table 26 having rollers 27 on which the rolled workpiece 23 is received.

The work rolls 20, 21 of each roll stand are disposed between a pair of back-up rolls 28, 29 which are in rolling contact with their respective work rolls 20, 21. The work rolls 20, 21 are rotationally driven, usually by electric motors (not shown), and due to the frictional contact between the back-up rolls 28, 29 and the work rolls 20, 21, the back-up rolls are also caused to rotate.

The roll load exerted on the workpiece 23 at each stand is measured by mill load cells (not shown) of any conventional type: the mill load cells will not be described since they are well known to those skilled in the art.

In the operation of the mill of FIG. 1, the workpiece, typically at a temperature of 1,200° C., is propelled by the rollers 25 of the support table 24 into the bite of the first roll stand F_1, and successively through the bites of the roll stands F_2 to F_6. The entry speed of the workpiece to stand F_1 would normally be in the range 300 to 400 feet per minute, while the exit speed from stand F_6 would be from 1,500 to 3,000 feet per minute.

The metal workpiece entering the bite of stand F_1 can have a temperature as high as 1,300° C.: as a result, the surfaces of the work rolls 20, 21 of stand F_1 and the succeeding stands F_2 to F_6 tend to be oxidized, scaled and pitted, and to mitigate this tendency, it is customary to cool each stand F_1 to F_6 by the passage of large quantities of water thereover. The water is supplied from headers, indicated diagrammatically by references 30, which are usually located mainly around the work rolls and sometimes around the back-up rolls of each stand F_1 to F_6 as indicated more accurately in FIG. 2.

Referring now to FIG. 2, there is shown adjacent each back up roll 28, 29 a respective nozzle 31, 32 which is of the type which discharges liquid passed therethrough in a divergent substantially planar spary. The nozzles 31, 32 are each mounted on a guide block 34 which can be moved along guide rails 33. Each block 34 is attached to a hydraulic cylinder 35 which has supply pipes 36 for a hydraulic fluid. By supplying hydraulic fluid to the appropriate one of the supply pipes 36, the blocks 34 and their respective nozzles 31, 32 can be moved towards or away from their corresponding back-up rolls 28, 29. For the purpose of illustration, the nozzle 31 is shown in a position adjacent the back-up roll 28, while the nozzle 32 is shown in a retracted position relative to the back-up roll 29, although it will be appreciated that during normal usage, both nozzles 31, 32 will be about the same distance from their respective back-up rolls 28, 29.

Each nozzle is supplied with liquid from a pipe 37 which is flexible so as to allow movement of the nozzle 31 or 32, and the flexible pipe 37 is connected to a source of liquid supply, to be described hereinafter, via a pipe 38 which is flexible at least for part of its length adjoining the flexible pipe 37.

It will be appreciated that when each nozzle 31 or 32 is nearest to its back-up roll 28, the width of roll sprayed will be smallest whilst when the nozzles are most retracted, the greatest width of back-up roll will be sprayed.

In order to avoid dissipation of the spray of liquid between the nozzle 31 or 32 and its back-up roll 28, 29, each nozzle together with its guide block 34 is enclosed in a hood or shroud 39 which is frusto-triangular in plan and closed on all sides except the side facing the back-up roll 28, 29.

The open side of the shrouds 39 are approximately the same width as the width of the back-up rolls 28, 29.

To prevent the heavy streams of cooling water provided from the headers 30 from deflecting the spray of liquid moving towards the surfaces of the various rolls 28, 29 and 20, 21 a deflector place 40 is attached on one side by a hinge 41 to the top of each shroud 39 and has its other side resting on the adjacent work roll. The deflector plate 40 extends the whole width of the shroud 39 and has a nylon edge 42 which rubs on the work roll the remainder of the deflector plate may be of wood or mild steel.

The liquid which is supplied to the nozzles 31, 32 at least during rolling operations comprises a liquid capable of forming on the back-up rolls 28, 29 a wear-resistant coating which is transferred, at least in part, to the work rolls 20, 21 as contact is made between the back-up rolls 28, 29 and the work rolls 20, 21. A suitable liquid is a mixture comprising predominantly an ester having a quaternary carbon atom in its molecule, such as pentaerithrytol tetraoleate, for example, in admixture with partially esterified pentaerithrytol and free carboxylic acids, the two latter components serving to increase the degree of adhesion of the layer of liquid.

The width of the back-up rolls 28, 29 sprayed, and hence the width of the work rolls 20, 21 to which a coating is applied will depend on the distance between each nozzle 31, 32 and each back-up roll. In the illustration of FIG. 2, the nozzle 31 sprays a relatively small width of back-up roll 28, and the liquid layer transferred to the work roll will be relatively narrow: this arrangement is suitable for the protection of the work roll 20 during the passage through the bite of a narrow workpiece. On the other hand, the retracted position of nozzle 32 enables a greater width of the back-up roll 29 to be sprayed so that a relatively wide liquid layer is transferred to work roll 21 to confer protection during the passage of a correspondingly wide workpiece through the bite. The different widths of the back-up roll 28 sprayed by the nozzle 31 at its extreme positions is shown in FIG. 3.

When the wear-resisting liquids comprising esters are employed, account must be taken of their marked lubricating properties, and to ensure that a workpiece enters the bite without slippage, the discharge of an ester-containing liquid is not commenced until a suitable interval after the workpiece has entered the bite. Similarly, it is desirable that the ester-containing liquid is volatilized or otherwise removed from the work rolls 20, 21 before a subsequent workpiece is received in the bite, and to this end, the discharge of ester-containing liquid is interrupted before the tail end of a workpiece has left the bite: the elevated temperature of the tail end of the workpiece causes the required removal of the ester-containing liquid. The means for regulating the periods of supply of the ester-containing liquid will be described hereinafter. In order to maintain the various nozzles 31, 32 clear and free of blockages, and to ensure immediate through flow of the wear-resisting liquid as soon as it is supplied to the nozzles without a pause while pressure is sufficiently built up in the nozzles, a continuous sprayed discharge of water from the nozzles 31, 32 is provided serving as a carrier liquid, the ester-containing liquid being dispersed in the water at appropriate intervals during the working cycle of each roll stand. When the supply of wear-resisting liquid is interrupted, the cutoff at the nozzles is correspondingly virtually immediate, due to the continued flow of the carrier liquid.

During the initial stages of a coffin schedule of rolling operation, the nozzles 31, 32 are relatively close to their respective back-up rolls 28, 29 so that a relatively narrow central strip of the back-up rolls 28, 29 is sprayed, and a liquid coating of about the same width as that on the rolls 28, 29 is transferred to the work rolls 20, 21.

As the coffin schedule proceeds, and wider workpieces are passed through the mill, the nozzles 30, 31 are retracted from the back-up rolls 28, 29 so that a greater width thereof is sprayed, and after the widest workpiece of the schedule has been rolled, the nozzles 30, 31 are incrementally moved towards their back-up rolls 28, 29 in accordance with the incremental decrease in width of successive workpieces.

From FIG. 4, it will be seen that the spray characteristic from commercially available spray nozzles is that for a substantial proportion of the spray width, between references 43 and 44, the rate of liquid discharge is substantially uniform, while outwardly of references 43 and 44 to the edges 45 and 46 of the spray, the rate of discharge is not uniform.

Since it is desirable that the workpiece-contacting surface of the work rolls 20, 21 should be uniformly coated, the width of the back-up rolls 28, 29 which is sprayed is wider than the workpiece: generally speaking, the spray should have a width at the back-up rolls 28, 29 which for most commercially available sprays is 110 to 120 percent of the width of the workpiece to ensure that a uniform liquid layer is transferred to the working surface of the work rolls 20, 21. The best relative width of the spray at the work rolls 28, 29 and the workpieces can be determined relatively easily for the type of nozzle employed by any convenient procedure.

The supply rate of ester-containing liquid to the nozzles depends on the nature of the ester, but obviously the wider the workpiece, the greater the supply will need to be: however, with too much ester-containing liquid, there may be slipping of, or uneven traction on, the workpiece in the bite (and this is particularly true with the widest workpieces), while with too little, there is erosion of the surface finish of the work rolls 28, 29. In addition, account must be taken of the speed of passage of the workpiece through each roll stand F: at high roll speeds, the contact time between each section of the workpiece and the work rolls 28, 29 is short, and the amount of ester-containing liquid required per unit area of the rolls 28, 29 to mitigate wear is lower than at low speeds. Finally, the rate of discharge of the ester-containing liquid needs to be varied in accordance with the thickness or gauge of the workpiece: for a thick workpiece, a high rate of discharge per unit area of the rolls is desirable but for thinner workpieces, less ester-containing liquid must be provided per unit area of the rolls if the quality of the rolled workpiece is to be maintained.

A typical correlation between the width of the workpiece, its gauge and the rate of discharge of ester-containing liquid for a given workpiece speed is shown in FIG. 5.

Referring now to FIG. 6, the control system shown controls the supply of liquid to, and the movement of, the spray nozzles 31*a*, 31*b*, for two back-up rolls 28*a*, 28*b* of different rolls stands.

The ester-containing liquid for mitigating wear of the work rolls (not shown), which liquid is hereinafter termed "the lubricant" for brevity, is stored in a tank 50 and pumped by a gear pump 51 in a circuit including a filter 52 and optionally a heater (not shown) conduit 53 leads from the circuit via a flowmeter 54 and then distributed the lubricant among a number of pipes 55*a*, 55*b*, . . . , each of which leads to a solenoid-operated valve 56*a*, 56*b* via respective metering pumps 57*a*, 57*b*. According to the operative condition of the solenoid-operated valve 56*a*, 56*b*, a regulated flow of lubricant can pass to a respective nozzle 31*a* or 31*b* via its supply pipe 38*a* or 38*b*. Any lubricant which does not pass to the nozzles 31*a* to 31*b* flows into a return pipe 58 via a respective non-return valve 59*a*, 59*b*, and is returned to the tank 50.

Water is supplied to the spray nozzles 31*a*, 31*b* by a pump 60 via respective supply lines 61*a*, 61*b*. The pressure of water in the lines 61*a*, 61*b* is less than that of the lubricant in the pipes 55*a*, 55*b*. Each supply line 61*a*, 61*b* incorporates a control valve 62*a*, 62*b* and terminates in a mixer unit 69*a*, 69*b*, wherein admixture of the water with the higher pressure lubricant can take place.

The movements of the nozzles 31*a*, 31*b* are effected by hydraulic cylinders 35*a*, 35*b* which are driven by respective hydraulic pumps 64*a*, 64*b*.

The control of the system of FIG. 6 is effected by any means capable of correlating the movements of the nozzles and the initiation and rate of discharge of liquids therefrom with the width of each workpiece and possibly also its gauge: conveniently, the said means may be an on-line computer, indicated by 65. The various functions performed by the computer 65 will be described but not its construction since the latter forms no part of the present invention and will be clearly conceivable by those skilled in the art.

Each roll stand is provided with a mill load detector cell 66*a*, 66*b* and the mill is provided with a width detector 67 for measuring the width of each workpiece entering and/or leaving the mill. The construction and mode of operation of width detectors is well known to those skilled in the art and will not be herein described.

The computer 65 receives a signal representative of the width of the workpiece from the width detector 67, signals of mill loading from the load detectors 66*a*, 66*b*, and also signals indicative of the positions of the spray nozzles 31*a*, 31*b* relative to a fixed part of the respective roll stand: any suitable position-responsive means such as potentiometers, variable resistances and photocells known to those skilled in the art may be employed to provide these signals.

According to the input signals received by the computer 65, the computer generates, or through amplifiers and/or relays, causes to generate, suitable output signals to the motors (not shown) driving the hydraulic pumps 64*a*, 64*b* for controlling the position of the nozzles 31*a*, 31*b*, to the water control valves 62*a*, 62*b* for regulating the flow of water to the nozzles 31*a*, 31*b* via the solenoid valves 56*a*, 56*b*, and to the solenoid valves 56*a*, 56*b* to open and close the valves and determine their degree of opening so that a desired flow of lubricant is mixed with the water at the mixers 69*a*, 69*b* for spraying from the nozzles 31*a*, 31*b* as a dispersion.

The operation of the system of FIG. 6 is as follows:

When a workpiece is about to be projected into the first stand of the mill, the workpiece width detector 67 provides a width signal which is received by the computer 65, together with signals indicative of the position of each nozzle 31*a*, 31*b*.

According to the width of the workpiece, as indicated by the width signal, the computer 65 causes the generation of signals to effect any necessary movement of the nozzles 31*a*, 31*b* relative to their back-up rolls 28*a*, 28*b* by actuating the hydraulic pumps 64*a*, 64*b*: the final positions of the nozzles 31*a*, 31*b*, is so chosen that in the width of back-up roll 28*a*, 28*b* sprayed, the proportion corresponding to the width of the workpiece is uniformly sprayed — i.e. the proportion corresponds to the width between references 43 and 44 of FIG. 4. In addition, the computer 65 causes the generation of signals to effect any necessary changes in the setting of the water control valves 62*a*, 62*b* so that at the chosen position of the nozzles 31*a*, 31*b*, the quantity of water passed to each nozzle will be sufficient to provide a desired uniform rate per unit area of the surface of the back rolls 28*a*, 28*b* rolling conditions — i.e. the rolling speed at each stand, the temperature and thickness and condition of the workpiece: all of these factors will be substantially known or determinable

The computer 65 regulates the opening and closing of the solenoid valves 56*a*, 56*b* in such manner that a predetermined flow rate of lubricant is supplied to the mixer units 69*a*, 69*b* for admixture with the water passing to the spray nozzles 31*a*, 31*b* just after the head end of the workpiece has entered the bite of the rolling stand so that no slippage of the workpiece occurs, and the supply of lubricant is interrupted before the tail end of the workpiece enters the bits so that the elevated temperature of the tail end of the workpiece will cause volatilization and/or combustion of the lubricant on the work rolls leaving them sufficiently free of lubricant to enable a subsequent workpiece to be gripped in the bite without slippage.

The provision of the signals for regulating each solenoid valve 56*a*, 56*b* by the computer is conveniently initiated by the signals from the load detector cells 66*a*, 66*b*: thus, in one method of control of the solenoid valves 56*a*, 56*b*, when a workpiece enters the bite of a roll stand, a signal is generated by the load detector cell of that stand which is received by the computer 65. After an interval of time which depends on the speed of the workpiece, the computer 65 generates a signal which initiates the opening of the solenoid valve 56*a* or 56*b* etc., so that lubricant is mixed and dispersed in the water supplied to the spray nozzle 31*a* or 31*b* at a desired rate which is in accordance with the known operation conditions at the roll stand. After another interval of time, when according to the known operating conditions at the roll stand, the tail end of the workpiece is approaching the bite of the roll stand, the computer 65 causes the solenoid valve 56*a* or 56*b* to close, so that the supply of lubricant to the spray nozzle 31*a* or 31*b* ceases, and the coating of lubricant on the backup roll 28*a* or 28*b* and the corresponding work roll is substantially removed as the tail end of the workpiece passes through the bite leaving the work rolls substantially free of lubricant before a subsequent workpiece is received in the bite of the roll stand.

In another mode of controlling the provision of lubricant, which mode is applicable to those roll stands from the second to the penultimate stands of the rolling mill, the opening and closing of the solenoid valves of a chosen roll stand is dependent on signals from the load cells of roll stands preceding and subsequent to the chosen roll stand. For example, if the chosen roll stand is the third in the mill, i.e. stand F_3 in FIG. 1, the solenoid valves 56 of stand F_3 are opened by a signal from the computer 65 when the head end of the workpiece in stand F_3 reaches the next consecutive stand F_4, the signal from computer 65 being initiated in response to signal from the load cell 66 of stand F_4: by the time the head end of the workpiece is engaged by stand F_4, the workpiece will be firmly engaged in the bite of stand F_3 and the possibility of slipping of the workpiece in stand F_3 is very remote. The closing of the solenoid valves 56 of stand F_3 to interrupt the supply of lubricant to the rolls of stand F_3 is conveniently effected when the tail end of the workpiece leaves the bite of the roll stand F_1 (that is to say, the first stand of the rolling mill of FIG. 1), as detected by the load cell 66 of stand F_1. The state of loading in stand F_1 is signalled to the computer 65 which then causes the solenoid valves 56 of stand F_3 to close. Accordingly, by the time the length of workpiece between the bites of stands F_3 and F_1 has passed through stand F_3, the lubricant on the rolls of stand F_3 has been removed by heat and/or oxidation to a sufficient extent to avoid or mitigate any substantial risk that a subsequent workpiece will not enter the bite of stand F_3.

It will be appreciated that some of all of the functions performed by the computer 65 can be effected manually, instead of automatically under the control of a computer (or other controlling device) as described in relation to FIG. 6. Thus, the regulation of the supply of water to the spray nozzles of each roll stand can be set by manually operable valves in place of the valves 62*a*, 62*b* of FIG. 6: such manually operable valves may be operated individually or from a single manual control: for manual operation of the valves, remote operation by pneumatic controls is most convenient on a large plant. The correct setting of the valves will be readily determinable since the rolling program will be known.

Similar, the positioning of the spray nozzle 31 can be effected by manual control in accordance with the known rolling program.

The supply of lubricant to each spray nozzle can be manually adjusted for flow-rate according to the rolling program, but the actual initiation and interruption of the supply to each pair of nozzles as a workpiece passes from one end of the rolling mill to the other is preferably controlled by the passage of the workpiece through the mill rather than manually: accordingly, the roll stand load detectors 66 of FIG. 6 may be employed to regulate the opening and closing of valves in their correct sequence and timing, the valves when open permitting lubricant to mix and disperse at mixer units 69*a*, 69*b*, in the water supplied to the spray nozzles 31 in the same way as do the solenoid valves 56*a*, 56*b*, except that the degree of opening of the valves is under manual control.

It will be understood that the term "manual control" hereinbefore referred to, comprehends all manner of control by human intervention, whether by direct manipulation of the item of hardware which is thus controlled or by indirect control in which a manually operated control is employed indirectly to effect control through relays and/or servo-means and/or amplifiers.

We claim:

1. A method for applying a lubricating wear-resisting liquid to at least one roll of a hot metal rolling stand in which metal strip varying in width is rolled, comprising:

a. projecting a divergent stream of said lubricating liquid upon a selected width of the surface of said roll from a movably mounted nozzle;

b. moving the nozzle toward and away from said roll;

c. regulating the flow rate of said lubricating liquid through said nozzle;
d. sensing the width of the metal strip being rolled;
e. coordinating the position of the nozzle relative to the roll surface as a function of the sensed width of the metal strip being rolled so that the selected width of the roll substantially corresponds to the sensed width of the metal strip and simultaneously varying the rate of flow of lubricating liquid from said nozzle as the nozzle position varies to provide a substantially uniform rate of liquid flow per unit area of roll surface being wetted by the lubricating liquid.

2. A method according to claim 1 in which the flow rate of liquid through the nozzle is coordinated with the distance of the nozzle from the surface according to a predetermined program.

3. A method according to claim 1 in which the flow-rate of liquid through the nozzle is adjusted manually in dependence with the distance of the nozzle from the surface according to a predetermined program.

4. A method according to claim 1 in which the nozzle movement is remotely controlled.

5. A method according to claim 1 in which the nozzle movement is remotely controlled and manually effected according to a predetermined program.

6. A method according to claim 1 in which the liquid forms a wear-resisting film or coating on the roll.

7. A method according to claim 1 in which a carrier liquid is projected continuously at the roll surface, and at predetermined periods in accordance with the operating program of the rolling stand, the wear-resisting liquid is dispersed in the carrier liquid.

8. A method according to claim 1 in which the wear-resisting liquid is immiscible in the carrier liquid and has a higher affinity for the surface of the roll than the carrier liquid.

9. A method according to claim 1 in which the wear-resisting liquid comprises an ester.

10. A method according to claim 1 in which the ester is a sterically hindered ester having a quaternary carbon atom in its molecules.

11. A method according to claim 1 in which the wear-resisting liquid comprises free carboxylic acid and/or partial esters having free hydroxyl groups.

12. A method according to claim 1 in which the wear-resisting liquid comprises free carboxylic acid, partial esters with free hydroxyl groups, and mixtures of both.

13. A method according to claim 1 in which the supply of wear-resisting liquid is initiated shortly after the head end of a metal workpiece has passed into the bite of the rolling stand and terminated shortly before the tail end of the workpiece passes into the bite of the stand.

14. A method according to claim 1 in which the supply of wear-resisting liquid is initiated shortly after the head end of a metal workpiece has passed into the bite of the rolling stand and terminated shortly before the tail end of the workpiece passes into the bite of the stand.

15. A method according to claim 1 in which the selected width is from 100 to 120 percent of the width of a workpiece which is to be rolled in the rolling stand.

16. An apparatus for applying a lubricating wear-resisting liquid to at least one roll of a hot metal rolling stand in which metal strip varying in width is rolled, comprising:
a. a nozzle mounted for projecting a divergent stream of said lubricating liquid upon a selected width of the surface of said roll;
b. means for moving the nozzle toward and away from said roll;
c. means connecting said nozzle to a supply of said lubricating liquid;
d. means for regulating the flow-rate of said lubricating liquid through said nozzle;
e. means for sensing the width of the metal strip being rolled;
f. coordinating means operably connected with the width sensing means for positioning the nozzle relative to the roll surface as a function of the sensed width of the metal strip being rolled so that the selected width of the roll substantially corresponds to the sensed width of the metal strip and for simultaneously varying the rate of flow of lubricating liquid from said nozzle as the nozzle position varies to provide a substantially uniform rate of liquid flow per unit area of roll surface being wetted by the lubricating liquid.

17. An apparatus according to claim 16 in which the nozzle movement is remotely controlled.

18. An apparatus according to claim 16 in which the nozzle movement is remotely controlled and manually effected according to a predetermined program.

19. An apparatus according to claim 16 in which there are two rolls disposed on opposite sides of the bite of the roll stand, there being for each of said rolls a nozzle movably mounted for projecting said liquid onto said roll.

20. An apparatus according to claim 19 wherein each roll is sprayed with liquid at a substantially desired rate per unit area over a predetermined width according to a predetermined program.

21. An apparatus according to claim 20 in which during a hot metal rolling operation, the nozzles are so located relative to their respective rolls that the width of the rolls sprayed is a fixed proportion of, and at least equal to, the width of the workpiece.

22. An apparatus according to claim 20 comprising means for controlling the concentration of a roll-coating liquid in the liquid projected from each nozzle according to a predetermined program.

23. An apparatus according to claim 16 comprising means for generating a first signal indicating that the head end of a workpiece has at least entered the bite of the rolling stand, means for generating a second signal indicating the approach of the tail end of the workpiece towards the bite, and control means which respond to the first signal to initiate the addition of the roll-coating liquid and which respond to the second signal to terminate the addition of the roll-coating liquid.

24. A rolling mill comprising at least one rolling stand comprising apparatus in accordance with claim 23.

25. A method according to claim 1 in which the nozzle movement is remotely controlled and automatically effected according to a predetermined program.

26. An apparatus according to claim 16 in which the nozzle movement is remotely controlled and automatically effected according to a predetermined program.

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